VIRGINIA GIS REFERENCE BOOK

General Application Category/Sub Application Name: Public Works/Service Authority – Facilities Mapping

Product, Service
Or Function Name: Storm Water Drainage System Inventory Applications

P/S/F/ Description: An application that aids the Public Service Authority/Public Works department in managing the existing storm water infrastructure and planning for future developments.

Product /Service/Function

1.) Spatial Data

Minimum Requirements:
The minimum requirements for spatial data for any application include those data that must be available to the application in order for that application to achieve its intended functional requirements. For a Storm Water Drainage System Inventory Application, these data include storm water system features, storm water collection areas, related information on system capacities, base data, and optional information on system conditions, weather conditions, and other related systems.

1.) <u>Storm water system collection areas</u>: These are vector polygon layers that depict man-made and natural features where storm water is collected, and the flow area boundaries. This information is sometimes generated through modeling or slope analysis and may exist in a digital format. In many cases this data must be defined through field research.
- Storm water run-off areas: boundaries of the system and subsystem areas that define the service area of the system or subsystem. A set of neighborhoods may all be drained using the same set of pipes and the same outfall. Attributes may include: a unique area ID, area name (possibly neighborhood name), area measure, an attribute to flag the existence of a contamination source, ground cover type (determines flow rates), system outfall (where does this water go?), location description, etc.
- Storm water holding areas or catch basins: vector polygons of man-made or natural areas where storm water run-off ponds or collects. Attributes may include: unique feature ID, feature name, feature type (pond, swamp, etc.), construction type (man-made vs. natural), holding capacity, outflow structure type, functional condition, system outfall (where does this water go?), location description, etc.

2.) Storm water system linear features: Vector line features representing flow paths designed to direct, or restrict storm water flow, such as canals, culverts, pipes, ditches, headwalls, wiers, dams, etc. These may be divided into man-made vs. natural or pipes vs. open features, but having them in one file will enable network flow path models. Attributes may include: unique feature ID, feature name, feature type (canal, pipe, etc.), size, construction material, system name, functional condition, maximum capacity, location description, etc.

3.) Storm water system inlets: Vector point features representing intake points where storm water enters a system, such as a drop inlet or yard drain. Attributes may include: unique feature ID, feature name, feature type (curbside sewer), system name, maximum flow capacity, system outfall ID, accepting feature (stream/water body/next system name/ID), location description, etc.

4.) Storm water system outfalls: Vector point features representing locations where storm water exits a system, such as pipe outlets. This information is useful in NPDES permitting and other discharge related activities. Attributes may include: unique feature ID, feature name, feature type (pipe, culvert end, etc.), system name, maximum flow capacity, number of feeder inlets, accepting feature (stream/water body/next system name/ID), location description, etc.

5.) Storm water system manholes: Point vector feature representing the locations of storm sewer manholes. These represent access points into the storm water pipes. Attributes may include a unique feature ID, feature type (manhole), size, descriptive location information (center of road, 100 yards up green-way trail from …, etc.), special access precautions, etc.

6.) Digital vector base map layers: Vector layers contain spatial features that are represented by points, lines, areas (polygons), or label points. The purpose of vector base map layers is to present enough background information so that the location and presentation of the storm water drainage system features will be clear to the user. This data should cover the entire storm water drainage system service area at a minimum, but including expansion areas for future development is recommended.

- Transportation infrastructure layers including roads, airports and landing pad locations, and railroads, will help locate storm water features but also have impact on the system as a whole. Structures that are a part of a transportation network; such as bridges and roads directly relate to how and where storm water flows. The run-off from a single airport or major road can greatly impact the features that must handle the concentration of water. Attributes may include: a unique feature ID, feature type (airport), feature name, an address (if applicable), contact information, and storm water drainage characteristics (gravity flow, piped, ditched, etc).

- Hydrographic features such as rivers, lakes, ponds, reservoir, swamps, oceans, bays, etc. should also be presented although the level to which they are collected should be determined by their apparent importance in locating an event. Small farm ponds are not likely needed, while city reservoirs and other major water features are important. Storm water systems generally yield their flow to hydrographic features. Attributes may include: a unique feature ID, feature type (reservoir), feature name, contact information (if applicable), storm water system ID. Hydrographic features, not including feature names, will also be available from the VBMP program for use with the orthophotography. Since this data is being compiled from the imagery, additional conflation should not be needed.
- Jurisdictional boundaries such as city, county, and state boundaries. Attributes may include: a unique feature ID, feature type (county boundary), and feature name.
- While related pollutant discharge data is important to the overall impact of this type of system, this paper focuses on system inventory. Please refer to the Storm Water Management Program paper for this type of information.

7.) <u>Geo-referenced orthophotography (raster base map)</u>: Geo-referenced orthophotography is aerial imagery/photography that is geographically or positionally accurate. It is typically used as an underlying layer or base layer that is presented below all other spatial information. Although geo-referenced orthophotography is not a minimum requirement, it is listed here since the VBMP 2002 orthophotography product will be an excellent base layer that will help users visualize storm water system collection areas, gain positional reference, and see geographic features that may be of importance to the system. Using imagery as a base gives a clearer visual representation of an area since it better represents what we actually see and includes all features in an area not just those selected for vector representations. It also helps present basic information on the elevation of objects. It is important to note that using an image base does not preclude the use of vector data. Image bases can not be used to store textual information for specific features, such as road names, nor can they be used to see all features since some features will be obscured by vegetation, steep terrain, shadows, and other image and ground anomalies.

8.) <u>Metadata</u>: Metadata is loosely defined as "data about data". In respect to spatial data, metadata is the descriptive information about the data's source(s), scale(s), intended uses, restrictions, development, projection parameters, history, etc. This textual information adds significant value to spatial data since it records and retains descriptive information about a given data layer. If personnel leave, descriptive information about the data remains. If the data is suitable to be used for other purposes (this can prevent redundant data collection) or if there is a problem with the data, the sources and processing steps can be analyzed since they are known. Detailed metadata should be collected, managed, and maintained for each data layer and should be made a requirement of any data created by a contractor. (See Standards/Guidelines Summary).

Before these data layers can be used together, they must be referenced to the same spatial coordinate system; and, then features may need additional positional adjustments in order for the features between layers to appear in the most appropriate place. (See information on Data Conflation Options.)

Optional Requirements:
Optional spatial data requirements include data that are more spatially or descriptively accurate, enable the application to perform additional, related functionality, or enable a more precise view/representation of the area. Some optional data would include the following.

1.) A digital parcels data layer that contains addressed parcel locations as polygons and additional property information such as owner name, occupancy status, business type, number of occupants, etc. can help a managing agency identify potential high impact areas for high run-off events. It can also be used to identify locations of the storm water system features and areas that need maintenance, such as eroded streambeds in residential areas. This is a set of polygons that has usually been collected for tax mapping purposes and contains extra information about an address and would include zoning information. This is used with a street centerline file to locate an address.

2.) A digital road centerline network shape file with valid and verified addressing information, preferably through the use of GPS and field verification. This spatial dataset would have more accurate feature positioning of addresses/locations by utilizing GPS fieldwork or conventional surveying methods. This is a more spatially accurate road data set that can be used for multiple purposes and will more accurately represent the location, size, and relationships between features.

3.) Flood plain management features and data that impact or are impacted by storm water run-off. These may include dams, levees, other flood control structures, flood plain boundaries, etc.

4.) More spatially accurate digital vector base map data (using GPS and/or surveys) or higher resolution aerial photography or digital orthophotography from multiple sensor types.

5.) Graphical/Spatial reporting of flooding or flow incidents.

6.) Additional planimetric reference data. This could be information, in the form of hydrology, building footprints, sewer and water system features, utility system features (gas, electric, telecommunications), and extensive road networks, etc. Some of these features can be collected directly from the VMBP imagery since they can be seen on the imagery.

7.) Current weather model generation overlay mapping.

8.) Hydrologic data that would enable flow modeling to show system impacts during varying categories of run-off events, including bridge and other structure models, and a graphic modeling system component.

9.) Wetlands data that identifies protected areas that may also be part of the natural component of a storm water run-off system and may affect storm water management improvement projects.

10.) Elevation data can be used to model the terrain's aspect, help identify water holding areas, and would be needed if flow modeling is to occur. The VBMP 2002 orthophotography program will contain a digital terrain model (DTM) that can be used to build elevation perspective models. The applicability of this product to a locality's storm water drainage system inventory needs will have to be evaluated by the locality.

2) Attribute Data

Attribute data is tabular information that stores characteristic of a geographic feature described by numbers, characters, or images, typically stored in a tabular format and linked in a table to feature model by a user-assigned identifier. While not required for all systems, using a relational database management system (RDBMS) to store and manage attributes is the recommended way of enabling efficient attribute storage and database designs. An RDBMS enables the establishment of table-to-table relationships that reduce redundant data storage and enable greater flexibility in database design. The current versions of the main GIS packages rely on some level of a RDBMS to enable their full functionality. The attributes listed here are in addition to the attributes listed directly with the spatial feature and are stored in related tables.

Minimum Requirements:
The only attributes that need to be tied to the spatial data are a feature identifier. All other attribute data can be stored in related tables. If this is used as an inventory system, than the attributes should include a unique feature ID, feature name, feature type, feature location description, system and/or subsystem name, and feature description.

Optional Requirements:

1.) Implementation of a city/county master street address guide (MSAG) that is the main address database for all locality purposes. All other datasets that have an address component should link to this MSAG with a unique identifier. This system would fall under the responsibility of the 911 operations. This would be a major undertaking in most cases; however, it would ensure that all addressing is from the same source and as accurate as possible. MSAG addressing can include the addressing of intersections, cemeteries, airstrips, airports, bridges, parks, structures, and could be used to more accurately locate (by address) features in a storm water system.

2.) Links to hazardous materials databases where available and feasible with attributes describing material types, recommended remediation methods, etc.

3.) Links to historical incident tracking databases where available and feasible, that would include incident identifiers, contamination areas, flow amounts, damage assessments, remediation steps, corrective measures to prevent future incidents, etc.

4.) Storm water modeling can be used to estimate the system impacts of development and appropriate fees can be collected to help off set that impact. In this case, a database of tax and/or fee data including parcel information, estimated impermeable area, fees, payments, owners, etc. would be needed.

3) Data Acquisition Options:

Data acquisition efforts should begin by inventorying available data in a systematic manor. Generally, a locality's data will be the most detailed and the data of choice. Start by inventorying the available data within the local departments, starting with the GIS or Engineering departments, and expand to the departments of adjoining localities or regional entities. If no local data exist, state, federal, and private sources can be checked, often using spatial data clearinghouses and other Internet searches. Data that is already in a GIS format, or have a spatial component from which a GIS layer can be generated will be the easiest to prepare but other good quality data should not be disregarded unless the georeferencing effort is not beneficial. Each data layer will need to be evaluated for its appropriateness and its metadata referenced for this purpose.

Storm water system feature data may exist in a public works or related department. This data typically exists only at the local level. While some of the features can be digitized from the orthophotography, such as ponds, ditches, etc., these will have to be field verified since many may be partially or fully obstructed by trees. Collection areas that are defined by the aspect of the terrain may be approximated from known locations on the imagery, but will require field verification or elevation data to more accurately position these types of lines (like basin boundaries).

Storm water system linear features may be identifiable from the orthophotography, or may be underground or under cover and not visible. Pipes and sewer locations may be available from as-built plans or maintenance records. Sewer openings may be too small to accurately discern from the orthophotography and may have to be collected in the field using GPS technology.

A digital vector base map data inventory should likewise start with the localities and work up to the small scale sources available from state and federal agencies. The TIGER/Line® data contain a road network with names and is free with the exception of media and re-production costs. This data will need to be conflated to the image base since it is not as spacially accurate. To make use of these data, a user must have mapping or Geographic Information System (GIS) software that can import the TIGER/Line® data since the Census Bureau does not provide these data in any vendor-specific format. Transportation features are also available from the USGS and may be available from the Department of Transportation.

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If additional base data layers are being utilized (listed above in optional requirements), this information will need to be collected and/or compiled. In some cases this spatial data will already exist in some manner. If information is on paper maps, then digitizing will need to occur. In most cases, basic framework data (see Standards/Guidelines Summary) will have already been compiled by a third party such as state and federal government entities. In all cases, the spatial base data will need to be verified for accuracy, clipped to reduce the data set to include only the service area, and possibly conflated (see below). Examples of third party spatial data may include road networks from VDOT, hydrography from USGS, utilities from local utilities, National Pollutant Discharge Elimination System (NPDES) locations from the EPA, etc.

A digital geo-referenced raster base map will be a very important component for this application. High-resolution digital orthophotography, or maps generated from these data will provide the most accurate base and will include many features visible from the air at a specific altitude. This data source will be available through the Virginia Base Mapping Project (VBMP) initiated by the Virginia Geographic Information Network (VGIN).

Hydrographic features, not including feature names, will also be available from the VBMP program for use with the orthophotography. Since this data is being compiled from the imagery, additional conflation should not be needed. Hydrographic line data and some name data are available from the USGS from the National Hydrography Dataset (NHD). Hydrographic names are available from the USGS in the form of the Geographic Names Information System (GNIS) and their locations can be conflated to overlay with the orthophotography.

Digital terrain model (DTM) data from which 3-dimensional perspectives can be created, will be a by-product of the VBMP program.

If addressing information is to be used, an Emergency Management, Land Records, or Planning department may have the required information.

4. Data Conflation Options:

Conflation is the method whereby a geographic feature is adjusted to fit a more accurate base map. Conflation will help to ensure that all locality data are positionally in the same space in relation to each other on earth. With the use of an accurate digital image, the position of associated vector data is conflated to overlay the position of the same features on the image base. Typically the best base map for conflation purposes is a current, high-resolution digital orthophotography product. It is paramount that the orthophotography is as accurate as possible since any error in the imagery will also be reflected in any feature that is located using that imagery. Feature layers that were created by on-screen digitizing directly from the orthophotography should not need conflation if the orthophotography is being used as the base.

The conflation process can occur in a variety of ways, with the least sophisticated being a "best-fit" methodology.

The best-fit method is a visual inspection or comparison of a geographic feature's current position to where it is or should be located on the more accurate base map. This method would either entail:

1.) moving the entire road lines layer across the imagery (like sliding one sheet of paper over another) until the greatest number of roads aligned as closely as possible with their counterparts on the imagery; or,
2.) moving individual road lines, or sets of road lines, so that they align as closely as possible with their corresponding road/s on the imagery.

These methods may be the best solutions in many cases since it will take less time than other options and will be the fastest to implement. Additionally, the availability of the VBMP orthophotography will provide a good base map in which to "fit" features. This method uses visual judgement to determine the best fit of the features.

Another conflation option includes rubber sheeting: a method using control points or existing boundaries to establish the new geographic position of a feature. Using roads as an example, control points at road intersections that can be clearly identified on both the digital imagery and on the road vectors are used to "stretch and shrink" the vector roads so that their positions correspond at the control points. The more control points that are used, the more precisely the data will fit. This method uses two sets of control points and an GIS algorithm to adjust the vector feature locations.

Finally, the most accurate method of conflating data includes the use of Global Positioning Satellite technology (GPS), or traditional survey instruments to accurately locate each desired object's physical location. While this is very accurate in most cases, the existence of an orthophotography base map product may be the best source for conflation because when viewing data/maps with different layers present, it is desirable to have the framework or vector data "fit" over the orthophotography. If a wide base of accurate GPS spatial data is already present then conflating the orthophotography may be satisfactory. This method uses direct field measurements, the most spatially accurate data as control points, and an GIS algorithm to adjust the imagery.

Any data not collected directly from the image base will likely need some level of conflation if it is to be overlaid effectively with the orthophotography.

5. GUI / Programming Options

A graphical user interface (GUI) enables a user to perform desired tasks by using a mouse to choose from a "dashboard" of options presented on the display screen. These are in the form of pictorial buttons (icons) and lists. Some GUI tools are dynamic and the user must manipulate a graphical object on the screen to invoke a function. For example: moving a slider bar to set a parameter value (e.g., setting the scale of a map). The GUI is the interface used to interact with the data and perform analysis functions.

A Storm Water Drainage System Inventory Application should have the ability to show storm water system features, the reference information used to locate the features, other related features or incident locations that relate to the system, and report the descriptive attribute information to the user. For inventory management, the ability to search for specific system components or input maintenance or repair requests could also be available. Links to ordering/inventory information with images, technical descriptions, and availability information on system components (replacement pipes, manhole covers, etc.) can also be part of the interface. This type of application is generally used by the managing agency and could optionally be made available to field personnel or emergency management staff. Some components of the interface may include:

1.) Input text boxes that enable searches against a database of system parameters can be used for both feature identification and for data input. There should be a one-to-one correspondence between the search components and the attributes in the database so that additional time does not have to be spent parsing the data before searching.
2.) A summary of the input information should be easily visible from the map view port.

3.) A map view port large enough for users to easily ascertain location information and object information.
4.) If the system has additional layers (other than storm water drainage system features) available in the application such as utilities, hydrology, building footprints etc., then the system should give the user the ability to turn certain layers on and off for reference purposes. This usually appears as a scrolling list of layer names and check boxes.
5.) The application interface should also give the user the ability to view historical event information for a particular location and give the user the ability to run additional queries.

GIS software can be modified utilizing a variety of programming languages or scripting languages that may vary depending upon the system architecture. This will enable the customization of the application interface and functions to meet non-standard requirements. Languages such as Microsoft Visual Basic are commonly used to invoke macros and customized functions such as GIS queries. Commonly used languages include: Visual Basic, C++, Java, HTML, ASP, ColdFusion, JSP, PERL, PHP and CGI.

For data that can be modeled as a "system" of interconnecting parts, certain GIS applications enable the development of "smart feature" models (called a GEO Database by ESRI). These allow feature characteristics to be defined within a database, enabling system constraints and functionality to be stored with the features. This reduces the amount of programming in the interface. For example: A pipe inventory stored in this type of system would present the pipes and connectors of the system graphically. If a user tried to place an inappropriate fitting between two pipes (a fitting that connects a 6 inch pipe with an 8 inch pipe would not be allowed between two 8 inch pipes) the system would flag the error and warn the user. This also helps when the system is being used for system maintenance.

6. Internet Functionality and Options

Internet functionality generally refers to public access to a system through the use of the Internet, or a public portal to a system that is password protected so that while the public can view the portal over the Internet, only authorized uses can gain direct access and use the application. These access types are generally enabled through a standard web browser. This is different than Intranet access, where access is limited to a specific computer network, usually one agency or group of agencies, and allows no public access.

A Storm Water Drainage System Inventory application is not usually publicly accessible and therefore not available to the public through the Internet. For access by field personnel, emergency services, planning, or other agencies, presenting this information over the Internet may be advantageous. If public viewing of the system's feature data or historical event data is desired, presenting it in a standard map window with related base data can be achieved fairly easily. These applications can take advantage of web browser interfaces, Internet transfer protocols and the flexibility of the Internet programming languages. Since web browser interfaces are so widely recognized and understood and since the programming languages are robust and enable the customization of the standard application interfaces, they are used in creating these types of applications. The advantage of Internet protocol interfaces is that data transfer is very fast.

Standard Internet mapping functionality would include basic GIS functions available in a thin client GIS application, such as ESRI's ArcExplorer (i.e. Zoom In, Zoom Out, Pan, Identify, Query, Thematic Mapping … etc.). Additional functionality may include appropriate hyperlinks to critical and related information on the Internet related to certain queries or operations within the application. An Internet application allows the organization to share its spatial and tabular information to all authorized users via a familiar Internet Browser interface. This eliminates multiple software license fees. Additionally, the Map Server (Web Server) is the only GIS hardware/software component that would be managed by the localities Information Technology Department.

7. Minimum Technical Requirements

The basic technical requirements needed to set up the GIS component of a Storm Water Drainage System Inventory are listed below.

1.) A Basic working knowledge of a leading GIS software, and Internet Browser are required.
2.) A Pentium III or greater CPU, with a minimum of 128MB Ram, 16MB Video Card, is required. A high speed Internet connection is recommended for GIS Internet application deployment and analysis.
3.) Most leading GIS software is customizable using MS Visual Basic or another common language. It is suggested that the developer have a working knowledge of (at least) Visual Basic before attempting GUI development.
4.) T1 or better connections to the Internet for access by field/response personnel.
5.) Server should be RAID level 5 with two stage back-up (mirrored systems as well as tape back-up) to minimize data loss and to enable quick data recovery.

Optimum Technical Requirements:
For a fully integrated mapping and a robust storm water drainage system inventory operation the options are near limitless. Below are some of the components that could be implemented to utilize the full benefit of a spatial/GIS based application.

1.) GPS units for all field data collection.

2.) A robust RDBMS networked to other departments as a central repository for all locality spatial data.
3.) Graphic modeling software for storm event modeling and condition predictions.
4.) An integrated work order system capable of tracking system conditions and managing work orders.
5.) Implementation of a 2-stage back-up and recovery system for rapid recovery of system failures.

In the case where a local government employs a highly capable Information Technology Department, other languages may be considered, such as JSP, Java, Visual Basic, ASP, and Cold Fusion. In most cases, these languages are related to Internet application development. A web developer with three years of experience should be able to customize and/or develop a unique Internet Map Server application.

8. Administrative / Management Requirements

A manager or administrator implementing a project of this nature will need a strong project management skill set due to the variety of the components that will be involved and have (or develop) a thorough understanding of the components of a storm water drainage system and its components. There are seven (7) main areas where administration and management requirements will need to be concentrated:

1.) Fiscal – Pre-planning and research on how other localities implemented similar systems is recommended. A manager with good fiscal, budgeting and money management skills will be helpful.
2.) Personnel - This type of implementation should require limited staff resources. If contractors are hired for any part of the implementation or maintenance, the manager would oversee their performance as well. Good personnel management skills will be required.
3.) Technology – A manager with a good understanding of GIS is recommended, but this type of application does not require extensive technical knowledge. The manager will need experience in selecting technical human resources.
4.) Political/Stakeholder Involvement – The ability to work with a limited number of external stakeholders may be needed. Emergency response or planning personnel may also want to be involved in this type of application for contamination response, accident response, future development planning, or Flood Planning, etc.
5.) Training – Training will likely be limited to the technical personnel running and maintaining the system and potentially the staff of other agencies.
6.) Operational – Day-to-day operations will be limited unless the locality is large and requires extensive daily maintenance. Scheduling may be required.

7.) Maintenance – Once the system is in place, on-going maintenance will need to occur. Before the system ever reaches this stage, the manager should be able to develop a plan identifying what resources are needed, what resources are expected to be available, and how maintenance will be performed. This will help guide the system requirements, and help ensure that and initial implementation is not undermined by the inability to support it over time.

In general, management concerns will involve technical support, system maintenance, and human resource management of technical staff. Technical and administrative issues become more critical and consuming when developing and/or hosting an application in-house. General expertise in GIS is suggested if outsourcing application development and hosting. In-house application development and hosting will require a GIS specialist, an advanced web programmer, and technical material resources (hardware/software).

9. Cost – Cost/Benefit

The specific costs and range of costs for this type of application will very greatly depending on the locality's needs, expectations, existing functionality and resources. The estimates below are approximations based on previously performed work.

Application Development: The cost of developing a storm water drainage system inventory application (programming a front-end GUI for the presentation and management of existing data) can range from $0.10 to $1.00 per service area customer, depending upon the availability and condition of existing facility data and the needs of the Service Authority or Public Works Department. 65% of this cost is attributed to the acquisition of the facility data. This assumes that most of the data has already been collected, staff are in place, and that the application will be used by that individual agency. Programming the application, which includes posting custom queries to the GUI, accounts for the remaining 35%.

Program Development: Developing a storm water drainage system inventory program from scratch, that includes: application development, data production, data conflation, hiring of staff, contract development/negotiations, multi-agency networking, database creation, field verification of data, all hardware and software, training, etc., could take up to three (3) years and run into the hundreds of thousands of dollars. Additional maintenance costs would also need to be projected.

The cost benefit of implementing a spatial application is that it will enable a better understanding of the system components and the impact they have on storm water run-off, and vice versa. This can help identify potential trouble areas and prevent costly repairs through preemptive system analysis. Time and money can be saved by using this type of application to more efficiently locate system features that need repair or that might need attention during storm events.

A storm water drainage system inventory program, that includes application development, can help save money by:

- identifying trouble, or potential trouble areas where major repair may have to occur if preemptive maintenance is not performed;
- enabling efficient scheduling of repair work and routing of service vehicles;
- identifying areas where storm water run-off directly impacts properties and can cause expensive and repetitive damage or lose of life;
- enabling the implementation of a system component maintenance program;
- enabling other programs to more accurately determine how storm water run-off effects their programs, such as floodplain management, planning, and emergency response; and,
- enabling efficient analysis of storm water flow for response to contamination events.

10. Standards / Guidelines Summary

In 1990, the Virginia General Assembly established the Storm Water Management (SWM) Program that set forth regulations regarding the following for State and Federal agencies (local agencies may choose to voluntarily comply): Land development activities, Mining activities, Tilling, planting and harvesting, and Linear development projects.

State guidelines and standards that effect the implementation of a storm water management system should be available by contacting the Virginia Department of Environmental Quality. More information: www.deq.state.va.us

The US Environmental Protection Agency (EPA) manages the NPDES permitting programs, has inventories on storm water management "best practices", and other water quality related information. More information: www.epa.gov

Many states and large municipalities have developed their own guidelines and standards for storm water management. It is recommended that adjoining counties and localities be contacted to gain this information.

Where applicable, industry standards for computer formats (including ANSI), Internet communications protocols (like TCP/IP), and other relevant technology standards should be used.

The Information Technology Resource Management Guideline, "Model Virginia Map Accuracy Standards", COV ITRM Guideline 92-1, 3/20/92; is a State of

Virginia Standard defining a common recognized standard to guide the collection of data for all map scales; a method for verifying and interpreting the data collected and map products produced; and a method of labeling data and map products. For more information: www.vgin.state.va.us/documents/guidelines-standards/guidelines-standards.html

The Federal Geographic Data Committee (FGDC), with consensus from local, state, federal, and private reviewers, created and maintain the "Content Standards for Digital Geospatial Metadata" (soon to become an international standard) to enable consistent and comprehensive recording of the content, quality, condition and other characteristics of spatial data. For more information: www.fgdc.gov

Seven (7) base map layers that have been recognized by the Federal Geographic Data Committee (FGDC), with consensus from local, state, federal, and private reviewers, are termed "Framework" layers. These layers are generally considered the main layers that most mapping organizations need to best enable and support their functions. They are: geodetic control, orthoimagery, elevation, transportation, hydrography, governmental units, and cadastral information. The FGDC has developed procedures, technology and guidelines (including basic attribute requirements) that provide for the integration, sharing, and use of these data and have also identified institutional relationships and business practices that encourage the maintenance and use of these data. For more information: www.fgdc.gov/framework

11. Startup Procedures/Steps

The need for the development of this type of application usually stems from an identified need for the service. Once this is recognized, a cost/benefit analysis will help determine if the resources and the benefits further warrant the development. If so, than the system itself can be addressed.

Regardless of whether the work will be performed in-house, or fully/partially contracted, a three-phase approach works well.

1.) Needs Analysis - The first step is to do a "**needs analysis**" on the current system, or planned system. This will clearly identify and record the goals and resource needs of the project and will later be used to define the project steps. A needs analysis should include:
   - the overall goals and expectations of the system;
   - an inventory of current and expected resources;
   - identification of components that need to be developed/added;
   - what types of products/documentation are expected;
   - what cooperative efforts and stakeholders will be involved;
   - what time parameters are involved;
   - what standards need to be used and what thresholds monitored; and,
   - how will the system be managed over time.

The needs analysis does not focus on implementation strategies, only on what the system needs to do and what resources will be need to be involved.

2.) With the needs analysis to guide and set goals, a **"systems design"** that meets those needs can be developed. This focuses on how the system gets built and determines:
    - what physical resources (specific hardware, software, etc.) will be used;
    - who will manage what components of the system;
    - where will the system reside;
    - who will build/manage/maintain each part of the system;
    - how will the system be used, step-by-step, to achieve the goals; and,
    - what type of specific, on-going support will be established.

    This focuses on the specifics of the system (the type, name, and size of computer), the human resources to manage it, and the way it will work and be maintained. The particulars of any given aspect may evolve as the system design is developed and specific questions or hurdles are discovered.
3.) Now that an actual design has been determined, an **"implementation plan"** describing how the system will be implemented needs to be developed. This begins the physical implementation of the system. The implementation plan defines the:
    - order of the implementation steps, (putting data in the system relies on the existence of the data);
    - time, money (costs), personnel resources, and stakeholders dependencies (this must occur in order for that to occur);
    - deliverables, formats, and documents by tasked entity (who does what, when and how);
    - implementation phases and task timelines (this task should take this long);
    - roles of the stakeholders, their expected tasks and commitments; and,
    - future implementation/maintenance tasks and how they get accomplished.

If the work is be contracted, than these documents should outline the role(s) of the contractor(s) as well. This is the step-by-step guide to "making the system".

Some specific project steps may include:

1.) Researching standards, available data, other implementations, and possible outside funding sources.
2.) Inventory existing/expected resources (hardware, software, staff, money, etc).
3.) Develop an application outline/blueprint, focusing on the application's purpose, interface design, functionality, querying capabilities, and "look and feel". Stakeholders should be involved in this step.
4.) The attribute data will need to be obtained from the various sources mentioned earlier and normalized and related where necessary. Spatial data will need to be compiled from a variety of sources, or, if it is not available, then it will need to be collected and developed.

5.) Determine the entity/entities that will be performing data development functions, application development functions and application hosting functions and create a project plan with budget numbers.
6.) Develop an implementation plan that includes timelines and milestones.
7.) Create a data development/transformation plan that includes metadata definitions, a database schema, and data dictionaries with relational information.
8.) Readdress your project plan, timelines and budgets as a final initial process before committing resources.

It is recommended that the database application functions be addressed and implemented before the mapping functions.

12. Estimated Time Line and/or Implementation (stand alone) Schedule

Time line and implementation schedules will be determined on an individual entity/locality basis since there is a very wide variety of implementation approaches based on the current status and position of a particular locality.

The estimated time to develop this application is as little as two (2) months or up to a year. The duration is defined by the availability and condition of storm water drainage system information. Typically a basic application can be developed in about 500 man-hours.

If the locality is planning a comprehensive overhaul or starting from the ground level, the data collection process, system implementation and integration may take up to three (3) years.

13. Best Practice Examples in Virginia

The NASA implementation referenced below is an on-line facilities master plan and facility management tool. The application tracks the storm water system, including storm water collection areas, drop inlets, and manholes. It is designed to help manage specific storm water management issues including safety, planning, engineering, and maintenance. The application includes an applet to track and manage the facility's storm water system. This applet is part of a larger application, but could also be implemented as a stand-alone application.

The project began with a lengthy data development effort, where all storm water system features were identified, located/verified, mapped and attributed. The data was processed into a GIS ready format that contained links to the external storm water database. This implementation has taken approximately three (3) months.

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